

ISO

ISO 25608

**Healthcare organization
management — Smart hospitals —
RTLS for portable devices**

First edition

PROOF/ÉPREUVE



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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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This document was prepared by Technical Committee ISO/TC 304, *Healthcare organization management*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The real time location system (RTLS) is transforming the management of healthcare environments, particularly in the tracking and utilization of portable medical devices. In a hospital, devices such as infusion pumps, ventilators, and portable imaging equipment are used for patient care, and RTLS technology enables hospitals to manage these assets more effectively. This technological advancement offers various benefits, in terms of operational efficiency, and patient safety. The RTLS provides real time visibility of device locations, which helps reduce the time staff spends searching for medical equipment. This capability not only improves response times in emergency situations but also optimizes device utilization across departments. It has been demonstrated that hospitals with RTLS implementations see improvements in equipment tracking, reducing delays in patient care and enhancing the flow of operations^{[1]-[2]}.

One of the key benefits of the RTLS is the ability to monitor equipment in real-time, ensuring that assets are not misplaced or underutilized. It has been shown that the RTLS reduces the misplacement of devices, lowering costs associated with replacement or rental of equipment^[3]. This visibility also contributes to preventive maintenance by supporting hospitals to monitor device usage patterns and schedule maintenance^[4].

The RTLS also helps enhance patient safety and care. By tracking the real-time location of both patients and devices, the RTLS ensures that the right equipment is available for the right patient at the right time, reducing medical errors associated with misallocated devices^[5]. Integration with hospital information systems (HIS) further streamlines operations, allowing automatic data collection and reporting for regulatory compliance^[6].

While RTLS offers numerous operational and clinical benefits, its implementation also requires consideration of patient acceptance, as well as ethical and privacy concerns. Protecting personal data—such as location information—is essential, especially in light of increasing data protection regulations.

The portable devices management using the RTLS is based on the lifecycle of portal devices outlined in this document, as illustrated in [Figure 1](#).

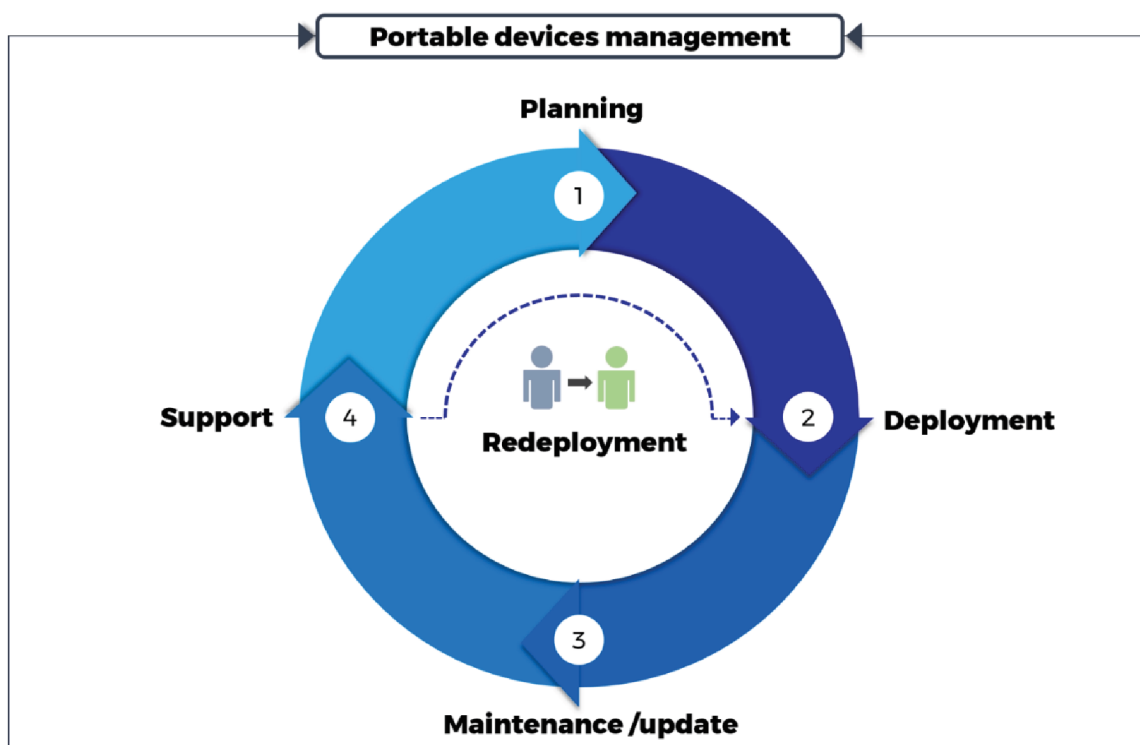


Figure 1 — Life cycle of portable devices management with RTLS

Healthcare organization management — Smart hospitals — RTLS for portable devices

1 Scope

This document specifies the requirements for efficient portable devices management in smart hospitals using the real-time location system (RTLS).

Out of scope:

- RTLS technical specifications (tags/beacons, scanner), refer to ISO/IEC 24730, 24770, and 24769 series;
- Network configurations or specifications for installing RTLS devices;
- RTLS testing and validation methods.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

Bluetooth Low Energy

BLE

low-power, mobile-compatible tracking technology ideal for real-time monitoring of patients and equipment, due to its efficient power consumption and compatibility with mobile device

3.2

deployment

process of installing and configuring RTLS tags on portable devices, establishing network connectivity to ensure effective location tracking

3.3

geofencing

creation of a virtual geographic boundary using location-based tracking technology to trigger actions like entry, exit, or movement tracking of a device within a specified area

[SOURCE: ISO 24311:2024(en), 3.4, modified — “by applying information and communication technologies such as those specified for intelligent transport systems (ITS)” has been removed and added “using location-based technology to trigger actions like entry, exit, or movement tracking of a device within a specified area.”]

3.4

healthcare

type of services is provided by professionals or paraprofessionals with an impact on health status

[SOURCE: ISO/TR 18638:2017(en), 3.10]

3.5

hospital information system

HIS

comprehensive, integrated information system designed to manage all the aspects of a hospital's operation

[SOURCE: ISO/TC 22218-2:2023(en), 3.10]

3.6

Infrared

IR

physical layer typically used by infrared data association (IrDA) devices

[SOURCE: ISO 11073-90101:2008(en), A.2.12, modified — “the” has been removed]

3.7

metadata

meta data

data that define and describe other data

[SOURCE: ISO/TR 3985:2021(en), 3.10]

3.8

portable device

medical or non-medical device that can be moved from location to location within the healthcare organization

[SOURCE: ISO/IEC 29145-1:2014(en), 3.1.11, modified — “, but uses network communications only while at a fixed location” has been removed and added “within the healthcare organization”]

3.9

Radio Frequency Identification

RFID

tags attached to equipment or patients are tracked using radio frequencies. They are divided into active RFID (battery-powered tags) and passive RFID (tags that use energy from a reader) and are used for asset tracking, inventory management, and patient monitoring

3.10

real time locating system

RTLS

a technology used to automatically identify and track the location of objects in real-time

3.11

redeployment

process of relocating or reassigning RTLS-tagged portable devices, including reconfiguration or recalibration of the RTLS tags to maintain accurate tracking in the new setting

3.12

ultrasonic

having a frequency above the audible range, i.e. above 20 kHz

[SOURCE: ISO 15463:2003(en), 4.1.126]

3.13

ultra-wide band

UWB

technology gaining popularity because it can track devices with high accuracy, down to the centimeter level, especially effective in environments where precision is critical, such as operating rooms

4 Stakeholder roles and responsibilities

Efficient implementation and management of RTLS-enabled portable devices require clear roles and responsibilities for all stakeholders. The following outlines the specific responsibilities for each group involved:

4.1 Healthcare organization leadership

- a) Example: hospital CEO, chief operating officer (COO)
- b) Roles and responsibilities:
 - 1) define strategic direction and priorities for RTLS deployment;
 - 2) allocate human resources;
 - 3) ensure compliance with regulations and policies.

4.2 Administrators

- a) Example: hospital administrator, designated nurse for RTLS
- b) Roles and responsibilities:
 - 1) coordinate distribution of RTLS-enabled devices;
 - 2) ensure documentation and user allocation.

4.3 RTLS implementation team

- a) Example: project manager, RTLS specialist.
- b) Roles and responsibilities:
 - 1) plan and manage the deployment process of RTLS systems;
 - 2) liaise with vendors and internal departments;
 - 3) validate RTLS system functionality.

4.4 IT Department

- a) Example: chief information officer (CIO), IT support specialist.
- b) Roles and responsibilities:
 - 1) integrate RTLS with hospital systems;
 - 2) ensure data security in place;
 - 3) maintain system functionality.

4.5 Operations and logistics team

- a) Example: asset manager
- b) Roles and responsibilities:
 - 1) manage RTLS-enabled device inventory;
 - 2) monitor device utilization;

- 3) implement procedures to minimize device loss and misplacement.

4.6 Staff end users

- a) Example: nurse, technician, clinicians.
- b) Roles and responsibilities:
 - 1) report device issues (e.g., malfunctions, loss, or usability issues);
 - 2) participate in RTLS training.

4.7 RTLS solution providers

- a) Example: RTLS vendor representative, technical support engineer.
- b) Roles and responsibilities:
 - 1) provide technology (e.g., hardware, software, and system integration services);
 - 2) customize RTLS solutions;
 - 3) deliver technical support, maintenance, and system updates;
 - 4) offer user training and documentation to facilitate adoption.

NOTE Patients are the direct recipients of healthcare services including portable devices, and their needs and feedback have a significant impact on the effectiveness of RTLS implementation.

5 Portable devices and potential benefits using RTLS

In hospitals, the RTLS is useful to various types of portable devices to improve tracking and management. These devices are vital for patient care. Some common types of portable devices to which RTLS technologies are applicable are as follows:

- infusion pumps;
- portable ultrasound machines;
- defibrillators;
- mobile X-ray machines;
- portable dialysis machines;
- portable IV stands;
- transport ventilators;
- glucometers and blood gas analyzers;
- patient beds and wheelchairs.

NOTE 1 Device types suitable for RTLS implementation

- a) Portable device: device that is portable and frequently moved, necessitating real-time location tracking.
- b) High-priority device: among portable and frequently moved equipment, those requiring the most effort by healthcare personnel to locate should be prioritized, especially when the number of available RTLS tags is limited.

NOTE 2 Device types not suitable for RTLS implementation

- c) Non-movable or rarely moved device: device that is stationary or seldom moved and does not significantly benefit from RTLS integration within existing operational processes.
- d) Device difficult to tag:
 - 1) cases where attaching an RTLS tag causes inconvenience during the equipment's usage;
 - 2) instances where the design or nature of the device makes it challenging to attach an RTLS tag effectively.

Implementing real-time locating systems (RTLS) in healthcare environments, particularly for nursing staff, provides multiple benefits aimed at improving efficiency and reducing workload burdens. Key advantages include:

- **Enhanced focus on patient care** - frees up time spent on non-clinical tasks to allow nurses to dedicate more attention to direct patient care;
- **Reduced time spent managing portable devices** - cuts down time spent on locating and managing portable medical supplies and equipment;
- **Streamlined shift transitions** - minimizes delays during shift changes by eliminating the need to locate and transfer portable devices manually;
- **Reduced stress** - helps decrease physical and mental strain of the nurses;
- **Improved mobility and workflow** - lowers excessive movement and walking distances within the facility, saving time and reducing fatigue;
- **Enhanced security** - enables theft prevention by monitoring real-time location data;
- **Real-time monitoring for immediate response** - provides immediate access to locations of portable devices for quick response in critical situations;
- **Objective data for decision-making** - leverages datasets to produce objective insights for allocation and management of portable devices.

6 Planning for RTLS in portable devices management

6.1 Planning and stakeholder engagement

- a) The hospital should develop a portable device management plan using RTLS.
- b) The hospital should engage stakeholders (IT, nursing clinical, operations) to determine workflow impacts and interdisciplinary collaboration.
- c) The hospital should consider the compatibility of the RTLS technologies with existing hospital infrastructure, especially network and security systems.

6.2 Identification of portable devices

- a) The hospital should conduct an audit of the portable devices to be included in the RTLS framework.
- b) The hospital should define the data fields for describing each portable device (mandatory and optional) (e.g., device type, designated department, device administrator).
- c) The Hospital should consider incorporating globally recognized standards for unique device identification (e.g., UDI) to enable cross-hospital device management and interoperability.

6.3 Policy development for portable devices management

- a) The hospital should define roles and responsibilities for RTLS operations.

- b) The hospital should incorporate provisions related to tracking, privacy, data access, and emergency protocols into existing medical equipment policies or management plans.
- c) The hospital should develop data security and access control measures.

6.4 Definition of data fields to describe RTLS-enabled portable devices

A set of data fields to describe each portable device shall be developed to be used when registering a portable device to RTLS application.

- a) (Device ID and Name) A unique ID and name shall be assigned to each portable device to ensure distinct identification.
- b) (Device category) Grouping of similar portable devices shall be developed in a hierarchical, multi-depth category structure for streamlined categorization of portable devices.
- c) (Department/ward) Information on the department or ward to which each portable device belongs may be used.
- d) (RTLS tag information) The ID and relevant information of the RTLS device (tag) attached to each portable device shall be used.
- e) (Hospital asset code) A hospital-managed asset code, if available, may be used for each portable device
- f) (Rental department/ward) The department or ward renting the portable device may be used
- g) (Manager ID) The ID of the individual responsible for managing the portable device may be included
- h) (User Department and User ID) The department and user ID of the current user of the portable device may be captured
- i) (Rental availability) It can be indicated whether the portable device is available for rental
- j) (Portable device supplier) The portable device's manufacturer, product name, model number, serial number, supplier should be stored

6.5 Functional requirements for RTLS

- a) The hospital should identify mandatory RTLS functions, such as locating accuracy, real-time notifications, and geofencing.
- b) The hospital should identify optional functionalities, such as usage analytics, for enhanced portable devices management.
- c) Functional requirements should consider the technical characteristics of different device types and usage scenarios. The expected level of performance (e.g., location accuracy, update frequency) should be defined to ensure consistent applicability across various clinical environments.

6.6 Compatibility with hospital infrastructure

- a) RTLS devices should be integrated with the existing hospital IT infrastructure.
- b) Level of access by the RTLS to the data in the hospital information system (HIS) should be considered.

7 Deployment of RTLS-enabled portable devices

Deployment of RTLS-enabled portable devices is to be carefully planned and implemented to minimize disruption to healthcare operations. Key considerations are as follows:

7.1 Device tagging and attachment

- a) RTLS tags shall be positioned in locations on each portable device that avoid obstruction of signal transmission.
- b) Each tag shall be firmly attached to minimize risk of detachment or damage.
- c) For devices frequently moved or subject to physical impact, durable and shock-resistant tags shall be selected to maintain functionality and accuracy.
- d) Devices that undergo regular cleaning or sterilization shall utilize waterproof or chemically resistant tags to prevent deterioration or loss of functionality over time.
- e) RTLS tags shall not obstruct the pressing of device buttons or alter the centre of gravity of the device, making the device difficult to use.
- f) RTLS tags shall be selected and positioned to avoid electromagnetic interference with medical devices, including implantable devices (e.g., pacemakers).

7.2 Data security and access control

- a) RTLS deployment should adhere to security standards practiced within the healthcare organization.
- b) Access to RTLS data (e.g., device location, movement history) shall be restricted to designated hospital staff with a direct role in portable devices management. In addition, data privacy protection measures (e.g., encryption, role-based access control, and compliance with applicable patient privacy regulations) shall be implemented to prevent unauthorized access and ensure the confidentiality of sensitive information.
- c) Regular audits of RTLS security protocols should be performed to ensure ongoing compliance with healthcare data protection standards.

7.3 Testing and validation

- a) Prior to full deployment, a testing phase should be conducted to validate RTLS functionality, ensuring that all tags communicate effectively within the designated areas of the hospital.
- b) Validation should include coverage checks to confirm that all intended locations are monitored, accounting for any signal interference areas or “dead zones”.

8 Maintenance of RTLS for portable devices

Ongoing maintenance of RTLS infrastructure is essential to uphold performance and reliability in the healthcare setting.

8.1 Software/firmware updates

- a) RTLS software and firmware should be regularly updated to incorporate security patches, performance enhancements, and new features that improve tracking accuracy and efficiency.
- b) Hospitals should establish a routine maintenance schedule for RTLS software updates, with a log maintained for each update and any issues encountered or resolved.

8.2 Performance monitoring

- a) Real-time monitoring of RTLS performance (e.g., device location accuracy, battery life, signal strength) should be conducted continuously.
- b) RTLS batteries should be selected with consideration for long operational lifespan to reduce the frequency of replacement and minimize operational disruption.

- c) A maintenance log should be maintained to document RTLS performance, device usage history, and interventions or repairs performed.

8.3 Alerts and communication

- a) Alerts for critical events - such as when devices leave designated areas, enter restricted zones, or require immediate maintenance - should be set up and transmitted to relevant personnel through multiple channels (e.g., mobile alerts, emails).
- b) Notifications should be customizable by event type, priority level, and relevant staff members.

8.4 Data backup and recovery

- a) Hospitals shall implement regular data backup procedures for the RTLS system to ensure that critical information (e.g., device location history, system configuration data) is securely stored.
- b) Recovery protocols shall be established and periodically tested to restore RTLS operations promptly in the event of data loss, corruption, or system malfunction.
- c) Backup schedules, storage locations (e.g., cloud-based or on-premises), and access controls shall be clearly defined to support business continuity and data integrity.

9 Support for RTLS-enabled portable devices

Effective support for RTLS-enabled portable devices enhances system reliability and staff efficiency. Support includes training, troubleshooting and support system.

9.1 Staff training and onboarding

- a) Comprehensive training should be provided to all the staff interacting with RTLS-enabled devices.
- b) Training should cover RTLS functionality (e.g., search portable devices by type), how to respond to alerts.
- c) Regular refresher sessions may be offered to ensure staff remain proficient in RTLS application, with new staff required to complete initial RTLS training as part of their onboarding.

9.2 Troubleshooting guide

- a) A detailed troubleshooting guide should be available to staff in charge of RTLS-enabled devices, covering common issues (e.g., device signal loss, tag detachment) and standardized solutions for each issue.
- b) Support personnel should categorize troubleshooting actions by urgency, enabling priority handling of critical issues, and establish response times for different issue categories to maintain service standards.

9.3 Defined support process

- a) A support process should be clearly defined, with a designated RTLS support team, a contact point or contact channels (e.g., email, phone) for staff inquiries.
- b) Documentation of all support requests and resolutions should be maintained to improve future response times and highlight recurring issues that can require system-wide solutions.

10 Redeployment of RTLS-enabled portable devices

Redeployment of RTLS-enabled devices shall follow defined processes to maintain system reliability and operational continuity.

- a) Redeployment cases should be identified (e.g., the device tag is damaged, or the device ownership is changed due to the device being assigned to another department).

- b) A standardized process for redeployment should be documented. This process shall include:
 - 1) unassignment of existing RTLS tag from the previous device record;
 - 2) physical inspection of the tag and device;
 - 3) reprogramming or replacement of the tag, as necessary;
 - 4) reassignment of the tag to the new device record or department;
 - 5) verification of the updated tag information in the RTLS database;
 - 6) confirmation of correct real-time tracking after redeployment.
- c) Responsibilities for each step in the redeployment process (e.g., RTLS system administrator, clinical engineering, IT support) should be clearly defined.
- d) Timelines for redeployment activities should be established to minimize downtime and prevent tracking gaps.
- e) Devices undergoing redeployment should be inspected for operational functionality.

Annex A **(informative)**

RTLS Use case

A.1 Overview

A.1.1 Development direction of RTLS

- a) Use various wireless technologies and sensors to determine the exact location and movement of objects indoors and outdoors
- b) Use in various fields, such as asset management, human resource tracking, and safety management

A.1.2 Elemental technology of RTLS

- a) Utilise various wireless technologies such as RFID, UWB, Wi-Fi, and bluetooth
- b) Transmitter (tag): attach to an object or person and send information related to its location
- c) Receiver: pre-processing basic information for processing location information by receiving the signal from the transmitter and sending it to RTLS software
- d) RTLS software engine:
 - 1) calculate the location information of the target by combining and analysing the data related to the location information received from the receiver;
 - 2) provides visualisation and analysis of relevant application services.
- e) RTLS related application services systems:
 - 1) using the finally calculated location information of the target, the end user service for the user (customer) is provided through the second and third data processing;
 - 2) according to the characteristics of these application services, various RTLS utilisation use cases are derived.

A.2 RTLS-related application services and use cases

A.2.1 Correlation between application services and use case

- a) The RTLS element technology that will be utilised depends on the application services under use.
- b) Application services correspond to use cases, and the key is to reflect the knowledge and demand of the business domain within the application services.
- c) RTLS-related application services that reflect domain knowledge and demand are ultimately directly linked to customer choice and the expected effectiveness of the smart hospital operation system.

A.2.2 Development path of RTLS in smart hospitals

RTLS, which was used to acquire location information only in the early stages.

- a) RTLS, which adopts bluetooth-based short-range wireless communication, is expanded and developed to acquire sensing data through connection and compatibility with bluetooth installed in wireless sensors such as various medical devices and hospital use thermometers.
 - 1) For instance, in the case of a smart thermometer with bluetooth, body temperature and location information are measured simultaneously.
 - 2) In addition, asset-tracking tags with additional motion-related sensors have been expanded to asset management services that use motion information to estimate the actual utilisation rate of assets.
- b) With the development of wearable medical devices, not only the location information of patients with wearable medical devices but also various types of vital information measured by wearable medical devices are also collected through the RTLS system and applied to real-time patient monitoring.
- c) Thus, RTLS has developed into a form that supplies source data to various application services by establishing itself as a key back-bone element technology for smart hospitals.

A.2.3 Applications of RTLS in smart hospitals (Examples)

Table A.1

Use case	Purpose	Function
1) Asset tracking	It is attached to various mobile medical/wearable healthcare devices or facilities (equipment) in the hospital to track the location of assets	Visualise the location of assets, or reduce business burden to find assets, or reduce the number of business burden
2) Asset management	Monitor or review the utilisation status of assets per ward by measuring the utilisation rate of actual assets based on additional information (e.g., movement) of the asset attachment location tag	Support for data-driven clinical and non-clinical decision making to identifying shortage or sufficient assets
3) Autonomous robot tracking	By identifying the location of mobile robots used in hospitals in the same form as asset tracking, it is used for abnormal appearance and failure measures of robots	Identify the location of the robot and use it as an aid if the robot cannot report its location
4) Accidental Infant misidentification	It is being used in several countries as a basic example of RTLS. Use location transmitters attached to mothers and newborns to prevent changes and kidnapping of newborns	Safety measures for newborns
5) Transfer team management	By identifying the location of the transfer team (transfer personnel) existing in a large hospital, all location and management of the transfer personnel focusing on short-range when demand for transfer occurs	Efficient operation of patient transfer team
6) Automatic records for special wards for infection control	In the case of special wards that require thorough infection control, such as emergency rooms and maternity wards, the access records of visitors are automated based on RTLS	Revised patient safety management act mandates the preparation of access records to major special wards (in South Korea)

A.3 Representative use cases of RTLS in South Korea

A.3.1 Asset tracking

Reduces healthcare personnel's burden of finding assets (e.g. portable or mobile devices) by visualising and tracking their location

a) Applied hospital

- 1) More than 50 hospitals including tertiary hospitals in South Korea (as of 2025)

b) Problems to be solved

- 1) In Korean hospitals, several mobile medical devices are arranged in each ward, and nurses in the ward are responsible for the management of these portable medical devices.
- 2) In the case of ward nurses, according to the order of doctors, the necessary treatment must be administered directly or prepared, and various medical devices must be prepared in advance during this treatment process.
- 3) However, owing to the nature of portable medical devices, determining their actual location is difficult, and owing to circumstances such as the loss and rental of other wards, the burden of preparing medical devices is placed on nurses.
- 4) Therefore, during the nursing shift (three shifts a day), the ward assets are checked manually through a separate transition list, and if the number is incorrect, satisfaction with nursing work is severely deteriorated owing to labour, such as searching the entire ward to find the assets.
- 5) The high turnover rate of new nurses owing to an increased workload not directly related to patient care is another issue for training medical healthcare personnel.

c) Application of RTLS

- 1) Attach the BLE Tag to major mobile assets and expensive equipment in the hospital and instal a receiver (IoT Gateway) in the ward to track the location of the BLE Tag in real time to track the location of the asset.
- 2) By adding a function to manage assets belonging to the ward separately, real-time detection of the departure of assets belonging to the ward.
- 3) One can quickly search for specific assets by adding a map-based asset search function in the ward.
- 4) In the course of the shift work, only the location within the ward is performed without manual checks.

d) Expected benefits

- 1) Focus on the original patient care work by reducing the burden of additional care work that is not directly related to patient care.
- 2) Increased satisfaction with nursing work owing to reduction of unnecessary work.
- 3) Automate the management of assets lost and rented.

A.3.2 Asset management

Manage the utilisation rate of assets in hospitals and increase their asset distribution efficiency.

a) Applied hospitals

- 1) Hallym University Sacred Heart Hospital
- 2) Gangdong Kyunghee University Hospital

- 3) National Health Insurance Ilsan Hospital

b) Problems to be solved

- 1) Several medical devices in hospitals have not been compiled for actual utilisation, and are being purchased and maintained.
- 2) Therefore, without knowing the actual utilisation rate of medical devices managed by a ward, some wards are assigned insufficiently and others are assigned excessively.
- 3) Furthermore, even with the same medical device, medical devices that are underutilised owing to frequent failures and lack of absence fees often remain in warehouses.

c) Application of RTLS

- 1) Automate the utilisation rate by acquiring the utilisation rate and utilisation rate of actual assets as additional information, in addition to tracking the location of assets in hospitals and wards.
- 2) Based on actual asset utilisation, use it in scientific maintenance, new purchases, and disposal procedures.
- 3) Redistribution of excessive and insufficient assets for each ward based on data.

d) Expected benefits

- 1) Rational resource allocation based on utilisation rate in hospitals for relatively expensive medical devices.
- 2) For critical sensitive medical devices whose performance decreases with utilisation time, preemptive preventive checks based on utilisation rates are performed to extend the life expectancy of assets.

A.4 Use case example at Henry Ford Health System(HFHS), USA

A.4.1 Organisation and purpose of implementation

The Henry Ford Health System (HFHS) is a major healthcare provider based in Detroit, Michigan.

This facility implemented an RTLS solution to address several operational challenges, including:

- a) increasing costs associated with rental of high-value portable medical equipment (e.g., intravenous (IV) pumps);
- b) difficulties in locating devices for recall, maintenance, or firmware upgrades;
- c) overall inefficiencies in asset operations.

A.4.2 Scope and mode of RTLS application

HFHS utilised a hybrid approach combining both passive and active RTLS systems.

- a) Passive RTLS is primarily used for inventory tracking and low-level stock management.
- b) Active RTLS-supported real-time asset tracking and enhanced operational control. The main functional applications included:
 - 1) real-time tracking of equipment locations (asset tracking);
 - 2) prevention of equipment loss and improved asset availability (asset management);
 - 3) maintenance of adequate stock levels within departments (low-level management).

A.4.3 Operational and financial benefits

The RTLS implementation enabled the real-time tracking of equipment locations, reducing the time required by the staff to locate the devices. This contributed to a reduction in equipment loss and avoided unnecessary re-purchasing. The system also improved asset utilisation, leading to increased efficiency in overall asset management operations.

A.4.4 Identified issues

The absence of a standardised system limited the full realisation of operational and financial benefits. Furthermore, the lack of defined technical specifications for components such as tags, readers, and communication interfaces restricted system interoperability and scalability.

A.4.5 Need for standardisation

This case highlights the necessity of standardisation in the application of RTLS within healthcare systems. The absence of a common framework at the HFHS has led to siloed deployments, thereby constraining overall efficiency gains. A standardised RTLS for portable medical devices is essential to ensure system-wide integration, interoperability, and sustainable operational benefits in complex healthcare environments.

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